SCIENCE CHINA
Life Sciences

SPECIAL TOPIC
• EDITORIAL •

October 2012 Vol.55 No.10: 841–842
doi: 10.1007/s11427-012-4391-y

Cutting edge advances in nanomedicine

XIAO Han & ZHANG YouYi*

Institute of Vascular Medicine of Peking University Third Hospital, Ministry of Health Key Laboratory of Cardiovascular Molecular Biology and Regulatory Peptides and Beijing Key Laboratory of Cardiovascular Receptors Research, Beijing 100191, China

Received September 20, 2012

Citation: Xiao H, Zhang Y Y. Cutting edge advances in nanomedicine. Sci China Life Sci, 2012, 55: 841−842, doi: 10.1007/s11427-012-4391-y

Nanomedicine is the application of nanotechnology in medicine and is a revolutionary area in medical diagnostics and therapeutics using nanoscientific materials, tools, techniques and insight. Nanotechnology is the understanding and control of matter and processes at the nanoscale (1–100 nm) in one or more dimensions where size-dependent phenomena usually enable novel applications (http://www.nano.gov/). This themed issue provides several reviews summarizing the recent development of nanotechnology in medical diagnostics and therapeutics, especially cancer therapeutics. In these reviews, the authors also included a lot of their own findings. Original articles investigated the biohazards of nanomaterials and provided new evidence for thrombosis mechanism using nano-based approach.

Some of the earliest nanotechnological applications are in molecular diagnostics, especially nanoparticle-based molecular imaging. Nanoplatform-based molecular imaging possesses unprecedented potential for early detection, accurate diagnosis, and personalized treatment of diseases [1]. Unique characteristics of nanoparticles make them attractive for molecular imaging. Because of smaller size, nanoparticles have significantly higher surface area to volume ratio. Nanoparticle surface can be decorated with therapeutic molecules, imaging agents, targeting ligands, or nucleic acids. Tong and co-workers [2] summarized the development of nano-structured and nanoparticle-based molecular imaging probes, and molecular machines using engineered nucleases for gene targeting. The best known nanoparticles, quantum dots (QDs), have been used as fluorescence imaging probes. Here, they discussed QDs which can be applied as fluorescence imaging probes, fluorescent protein FRET probes and molecular beacons. The advantages of QD labels are their extremely high photostability, high identification accuracy and controllable colors. As imaging contrast agents, nanoparticles circulate in the blood for longer periods of time with higher sensitivity and possibly fewer side-effects. In addition, they introduced the development of novel engineered molecular machines that can quantify, control and manipulate biological functions in living cells for disease treatment. They also discussed the challenges of these nanotechnological applications.

For several years, nanotechnology has been developed in cancer for diagnosis (detection and imaging), treatment and prevention [3]. The promising characteristics of nanoparticles raise the development of theranostic applications which combine both therapeutic and diagnostic purposes [4]. Theranostic nanoparticles can be delivered to the target area for imaging while act as therapeutic agents. Nie and Chen [5] presented an overview of Au nanoparticles applications in cancer theranostics which includes cancer diagnosis (imaging based detection) and cancer therapy (photothermal therapy, anti-neoplasia and drug delivery). The ability of Au nanoparticles in efficient light absorption followed by rapid heat conversion makes them become the promising candidates for cancer hyperthermia treatment. Au nanoparticles also have the anti-neoplastic and anti-angiogenesis effects. Like most nanocarriers, Au nanoparticles also have several advantages when serving as drug delivery vehicles. Unlike other antitumor agents or nanomaterials, $Gd@C_{82}(OH)_{22}$ nanoparticles do not directly kill tumor cells but inhibit tu-

*Corresponding author (email: zhangyy@bjmu.edu.cn)

mor growth and metastasis [6]. Li and co-workers [6] discussed $Gd@C_{82}(OH)_{22}$ nanoparticles in terms of physiochemical properties and antineoplastic activites, as well as its underlying mechanisms on tumor microenvironment regulation.

Biosafety is the most concerned area in nanotechnological applications. *In vitro* cell culture has been routinely used for nanoparticle toxicity assessment. However, excessive subculturing could disturb the cultured cells properties. Guo and co-workers [7] assessed the effects of silver nanoparticels (AgNPs) on different passages of Ba/F3 cells to see if the cellular response upon nanomaterial exposure is consistent enough to evaluate the nanoparticle toxicity.

In basic research, nano-based technologies provide us new evidence or models which cannot be acquired by the traditional approach. Most *in vitro* studies usually analyze conventional 2D cell-culture that fail to reconstitute the *in vivo* cellular microenvironment. Three-dimensional tissue-like structure models create cell-culture microenvironments that both support tissue differentiation and recapitulate microenvironments in living organs [8]. However, it is still a great challenge to construct tissue-like structures with microscale features. Recent developments emphasize the nanotechnological applications for cells manipulation to reconstitute tissue-like structures. Gong *et al.* [9] summarize the currently available microscale methods that control mammalian cells to assemble into tissue-like structures.

Nanotechnology includes visualization and manipulation on nanoscale. The atomic force microscope (AFM) is frequently used to investigate the interaction forces (e.g., ligand receptor binding) and the mechanical properties of living material in three dimensions, with resolutions as high as 0.1–0.2 nm. In contrast to the conventional microscope, the AFM can be applied in the investigation at the molecular level and under near physiological conditions [10]. In the current issue, Wei *et al.* [11] investigated the mechanism of cigarette smoking triggered thrombosis. They used AFM based single molecule force spectroscopy to investigate the thrombomodulin (TM)-thrombin binding *in vitro* and in living cells. They found that cigarette smoke extract (CSE) treatment dose-dependently lowers binding probability for thrombin and TM extracellular domain (TM-ECD) binding onto the silicon substrate. Interestingly, they discovered that CSE did not affect the thrombin/TM binding force. Using AFM combined with fluorescence microscopy, they investigated the single-molecule force of thrombin/TM in the living cells expressing TM-EGFP. They also found that CSE dramatically reduces the binding probability of thrombin/TM in the living cells. In conclusion, CSE inhibits thrombin/TM binding both *in vitro* and in living cells [11].

The main goal of this themed issue is to provide a survey of how nanomaterials and nanotechnology improve our basic and clinical research. We hope that you will find them inspiring and useful for your research.

1 Cai W B, Chen X Y. Nanoplatforms for targeted molecular imaging in living subjects. Small, 2007, 3: 1840–1854
2 Tong S, Cradick T J, Ma Y, *et al*. Engineering imaging probes and molecular machines for nanomedicine. Sci China Life Sci, 2012, 55: 843–861
3 Siddiqui I A, Adhami V M, Chamcheu J C, *et al.* Impact of nanotechnology in cancer: emphasis on nanochemoprevention. Int J Nanomed, 2012, 7: 591–605
4 Wang L S, Chuang M C, Ho J A. Nanotheranostics—a review of recent publications. Int J Nanomed, 2012, 7: 4679–4695
5 Nie X, Chen C Y. Au nanostructures: an emerging prospect in cancer theranostics. Sci China Life Sci, 2012, 55: 872–883
6 Li Y Y, Tian Y H, Nie G J. Antineoplastic activities of $Gd@C_{82}(OH)_{22}$ nanoparticles: tumor microenvironment regulation. Sci China Life Sci, 2012, 55: 884–890
7 Guo D W, Zhang X Y, Huang Z H, *et al*. Comparison of cellular responses across multiple passage numbers in Ba/F3-BCR-ABL cells induced by silver nanoparticles. Sci China Life Sci, 2012, 55: 898–905
8 Huh D, Hamilton G A, Ingber D E. From 3D cell culture to organs-on-chips. Trends Cell Biol, 2011, 21: 745–754
9 Gong P Y, Zheng W F, Xiao D, *et al*. Microscale methods to assemble mammalian cells into tissue-like structures. Sci China Life Sci, 2012, 55: 862–871
10 Jain K K. Nanotechnologies. In: Jain K K, ed. The Handbook of Nanomedicine. Totowa: Humana Press, 2008. 14
11 Wei Y J, ZHang X J, Xu L, *et al*. The effect of cigarette smoke extract on thrombomodulin-thrombin binding: an atomic force microscopy study. Sci China Life Sci, 2012, 55: 891–897